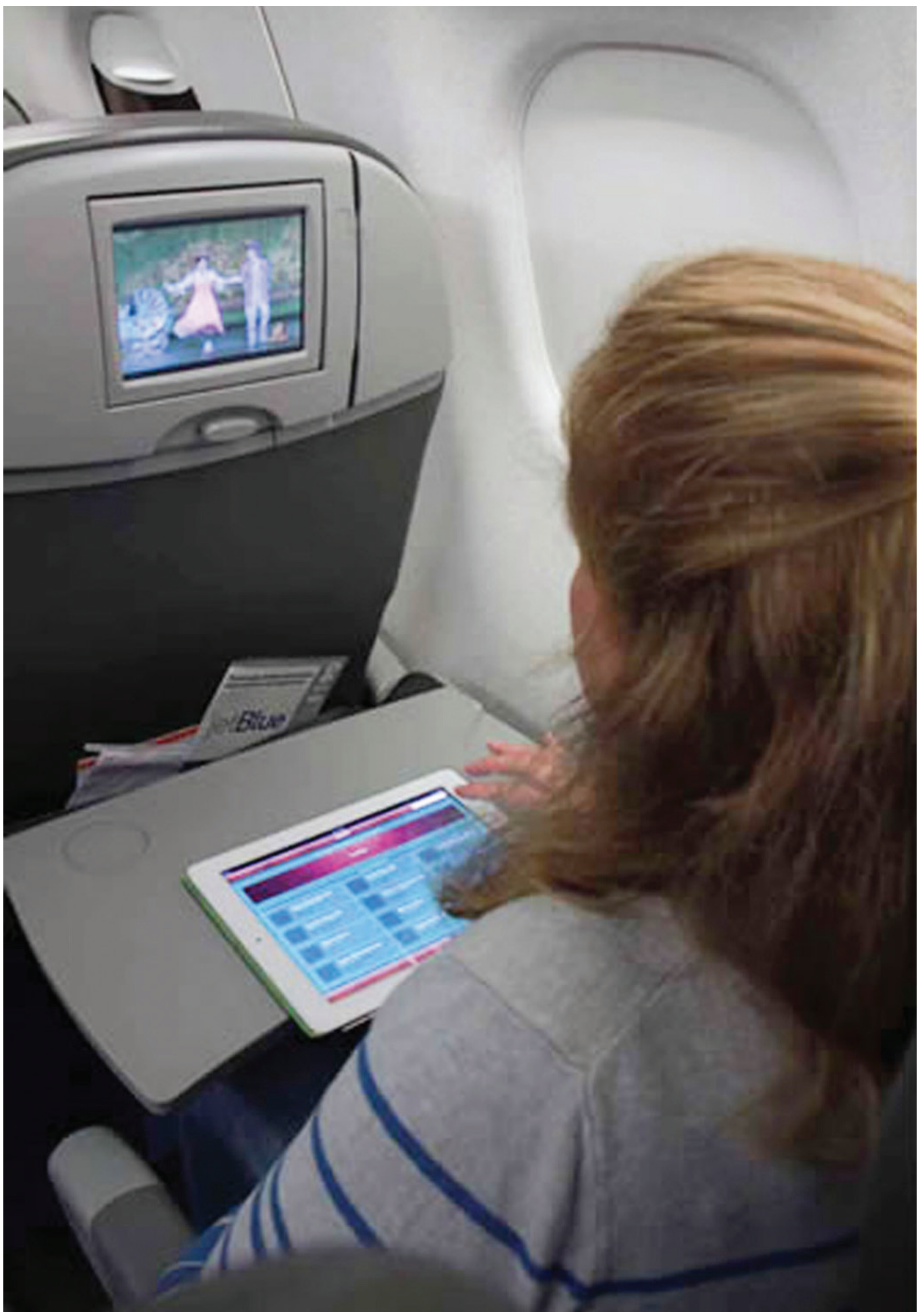
Reprinted From: HIGH PERFORMANCE COMPOSITES Magazine

Composites aid connectivity on commercial aircraft

General Dynamics' triband radome helps LiveTV team overcome transmissivity challenges during development of in-flight broadband services.

BY GINGER GARDINER

Source: Live TV



Inflight entertainment and communications is a $2 billion industry, according to a 2012 report by MarketsandMarkets (M&M, Dallas, Texas), and by 2017, it could reach $3 billion. Beyond TV and video games, airline passengers now want to access a full range of services on their mobile devices, including smartphones and tablet PCs, at the same connection speeds they experience at home. By year's end, according to the IFExpress web portal (http://airfax.com/blog/index.php/2013/01/08/2013-ifec-predictions/), "mobile Internet traffic will surpass fixed, and a lot of those users will be using them on planes."

Foreseeing this trend, JetBlue Airways (Long Island City, N.Y.) announced in 2010 that it would develop and launch the industry's best in-flight broadband for commercial flights, using ViaSat's (Carlsbad, Calif.) innovative high-capacity satellite technology, with the bandwidth to meet growing demand.

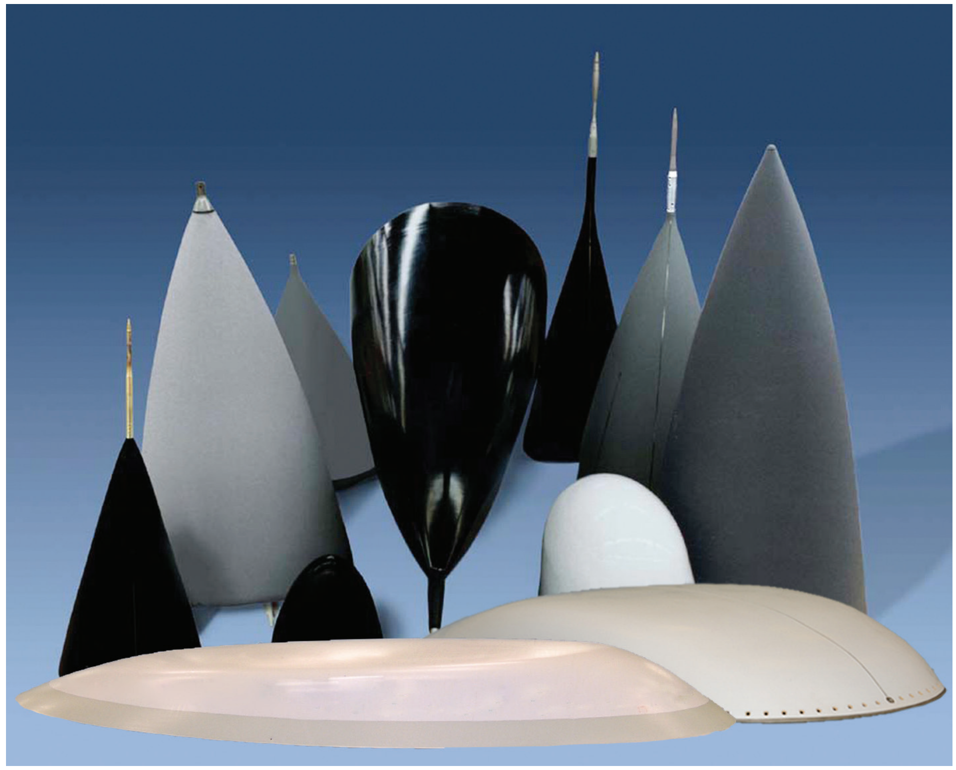
That same year, General Dynamics Armament and Technical Products (GDATP, Charlotte, N.C.) developed a concept for a composite radome that would allow the enclosed antennae to transmit and receive radio frequency signals across a broader range of bandwidths. Thus, when LiveTV (Melbourne, Fla.), a wholly owned subsidiary of JetBlue Airways and the system integrator for the project, held a competition for such a radome in 2011, GDATP was well-positioned to meet the challenge. The company won a $10 million contract from LiveTV in 2012 to develop and produce *triband* radomes. Combined with ViaSat's antennae and LiveTV's onboard delivery systems, they

In-flight broadband

To enable "at-home" connectivity on commercial aircraft, LiveTV developed tri-band satellite technology to provide the broad bandwidth necessary to achieve the processing speed and breadth of services airline passengers desire.

Broadband-capable

General Dynamics Armament and Technical Products (GDATP) has developed and built radomes for over 60 years, a fact that gave the company an edge as it sought solutions to the technical challenges of developing a triband radome (front row, left) for Live TV's inflight connectivity project.



Source: General Dynamics

would enable high-capacity two-way communications and Wi-Fi.

Broader bandwidth

Traditionally, *bandwidth* is a range of frequencies within a given band for transmitting signals, such as radio waves. But it also describes the amount of data that can be transferred over a connection per unit of time. Dial-up connections provide low- or narrow-bandwidth service. DSL, cable and satellites deliver high- or broad-bandwidth services (*broadband*, for short). A *triband* data connection is one that uses *three* bands, in this case, the K, K_u and K_a bands, to deliver as much signal bandwidth — that is, speed and connectivity — as possible.

These bands reside within the microwave part of the electromagnetic spectrum (see Table 1). as defined by the Radio Society of Great Britain (Bedford, U.K.). The K designation comes from the German word *kurz*, meaning short. K_a means "K-above"; and K_u means "K-under." These terms describe the bands directly above and below the K band, respectively.

"We started this project in September 2010. JetBlue had just made the announcement to work with ViaSat, and three of our main competitors" — GoGo (Itasca, Ill.), Row44 (Westlake Village, Calif.) and Panasonic Avionics Corp. (Lake Forest, Calif.) — "had launched Air-to-Ground systems or were developing K_u-band satellite technology," explains Mike Moeller, LiveTV's VP of sales and marketing "We decided to bypass these due to our belief that the consumer demand for inflight Internet services was going to increase dramatically, and more bandwidth would be required to accommodate the desired speed and services to provide an 'At Home in the Air' experience." Believing its product would need to withstand a large increase in demand over the next 10 years, LiveTV took the risk. "Our decision," says Moeller, "was to pursue new technology that was not yet proven but would be groundbreaking if we could pull it off."

That pursuit required a new kind of radome. Moeller notes, "We had to reach outside the traditional providers in commercial aviation, and identified General Dynamics, who had a vast experience in radome development."

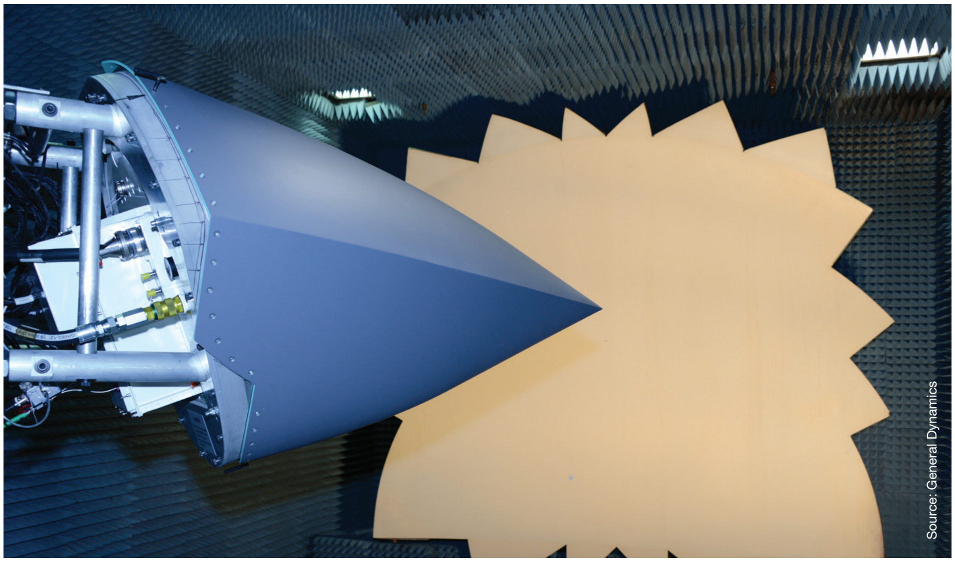
3x technical challenge

GDATP's solution looks like other radomes, but that belies the technical achievement.

Frequency Band		Frequency	Frequency Band Use
Radio and Broadcast		600 kHz to 1.6 MHz	AM radio
		88 to 108 MHz	FM radio
		54 to 700 MHz	TV broadcast
Microwave	L band	1 to 2 GHz	Cell phones 0.9-2.4 GHz Microwave 2.4 GHz Wireless Data 2.4 GHz Radar 1-100 GHz
	S band	2 to 4 GHz	
	C band	4 to 8 GHz	
	X band	8 to 12 GHz	
	K_u band	12 to 18 GHz	
	K band	18 to 26.5 GHz	
	K_a band	26.5 to 40 GHz	
	Q band	30 to 50 GHz	
	U band	40 to 60 GHz	
	V band	50 to 75 GHz	
	E band	60 to 90 GHz	
	W band	75 to 110 GHz	
	F band	90 to 140 GHz	
	D band	110 to 170 GHz	
Terahertz		1 to 10 THz	Bio-imaging
Infrared		300 to 400 THz	Remotes, night vision
Visible Light		400 to 800 THz	
Ultraviolet		800 THz to 30 PHz	Dental curing, tanning
X-ray		30 PHz to 30 EHz	Baggage screening
Gamma		> 30 EHz	PET imaging

Table 1: Chart of the electromagnetic spectrum.

Source: Southeastern Universities Research Assn. and the Radio Society of Great Britain



Better radomes through in-house testing

GDATP maintains 16 different test ranges, such as this one used for the F-35 radome transmissivity measurement, at its Marion, Va., design and production facility.

"Typically, radomes are configured and optimized for a relatively narrow frequency bandwidth, for example, just K_a or just K_u," says Daran Eastridge, GDATP senior program manager. Because LiveTV needed a triband solution, which meant optimizing a radome for a broad slice of frequency bandwidth, it also needed systems antennae to transmit and receive at these distinctly different frequencies simultaneously.

Developing a radome to accommodate a wide bandwidth is difficult because *any* material selected for the project will vary in its response to the electromagnetic waves passing through it. "At some frequencies, it will let the signals pass, and at others, the material will attenuate the signal," Eastridge explains. "A stack of materials that will readily allow transmission at one frequency will often produce more loss at another frequency."

For that reason, GDATP selected a quartz fiber/epoxy prepreg from TenCate Advanced Composites USA (Morgan Hill, Calif.) instead of a more conventional combination, such as glass fiber/epoxy or quartz/cyanante ester products. "We needed the transmissivity performance of quartz," Eastridge explains. "However, quartz put a strain on the project budget. The design parameters allowed us to use TenCate's epoxy resin, which helped us to meet both the desired performance and cost savings for this application."

Beyond broadband transmissivity, the triband radome had to maintain the lowest possible profile to preserve aircraft aerodynamics and meet a strict weight requirement, yet provide ample clearance for the antenna hardware within.

Thus, the design process for a wide-bandwidth radome involves a complex analysis with many interdependent variables, including not only materials and the various signal processing options they offer, but also their shape and thickness. "You also must select materials that will enable consistency in signal transmission from part to part," adds Eastridge. "Every radome on every plane must act the same and for a lifetime of 20 years or more."

Experience provides solutions

Capability-wise, GDATP was in the right place at the right time. "Our military radome experience goes back to the late 1940s," says Eastridge, "but we have also worked on commercial applications, including Boeing's satellite-based Connexion inflight Internet service, launched in 2001." He notes that military jets have been moving toward broadband for 20 years. "We have worked on ... the F-15 and F-18 radar modernization programs, and have developed a lot of experience in tailoring composites to uncharacteristically wide frequency bands."

A key to success during those two decades was GDATP-developed proprietary radio frequency (RF) software, which is used to analyze the impact of various materials on RF signal transmission. "We can very accurately model what the impact of a given material will be and [do so] in a 3-D spatial configuration, including variations in radome geometry," Eastridge points out. Beyond computer-aided signal modeling, GDATP has computer-aided structural analysis capabilities and uses them concurrently to iterate and refine the radome design. "The RF and structural designers work hand-in-hand, which cuts the time and cost of development."

GDATP analyzed several radome profiles that LiveTV and ViaSat had identified as possible solutions along with options developed in-house, then performed trade studies to identify the optimal solution. "We had actually looked at this prior to being contacted by LiveTV," explains Eastridge, "because we could see that aircraft communication systems were going toward K_a and K_u bands due to the advantage it offers for Internet service. So we already had a start on the problem when LiveTV contacted us."

"This really benefitted us," LiveTV's Moeller acknowledges. "And they have so much expertise in highly technical radome development, it has helped guide the solution quickly, saving us valuable time and unnecessary expense." Moeller adds that there is also a great deal of reliability in the GDATP radome.

The program concluded with testing to validate performance and certify first articles to U.S. Federal Aviation Admin. (FAA, Washington, D.C.) requirements — no small thing, Eastridge admits. "FAA certification requires extensive materials testing, as well as impact and lightning strike tests," he explains. GDATP's 16 different test ranges in Marion, Va., offer a wide range of RF, impact and load testing capabilities. "We are used to this," he says, "and well-prepared for it." As GDATP finishes the last of the FAA certification tests and prepares to deliver conforming units to JetBlue, Eastridge says the whole team is pleased with the radome's performance, including ViaSat, which tested it independently.

When JetBlue launched LiveTV in 2010, offering 36 channels of DIRECTV broadcast on its aircraft, it committed to having the industry's first in-flight broadband service by the first half of 2013. "That gave us a little over two years to get this right. But we've done it." Although in-flight trials, FAA certification of other hardware, preparation for fleet-wide installation and lots of paperwork remain, "the whole team is committed and we remain on schedule for launch this year." ■

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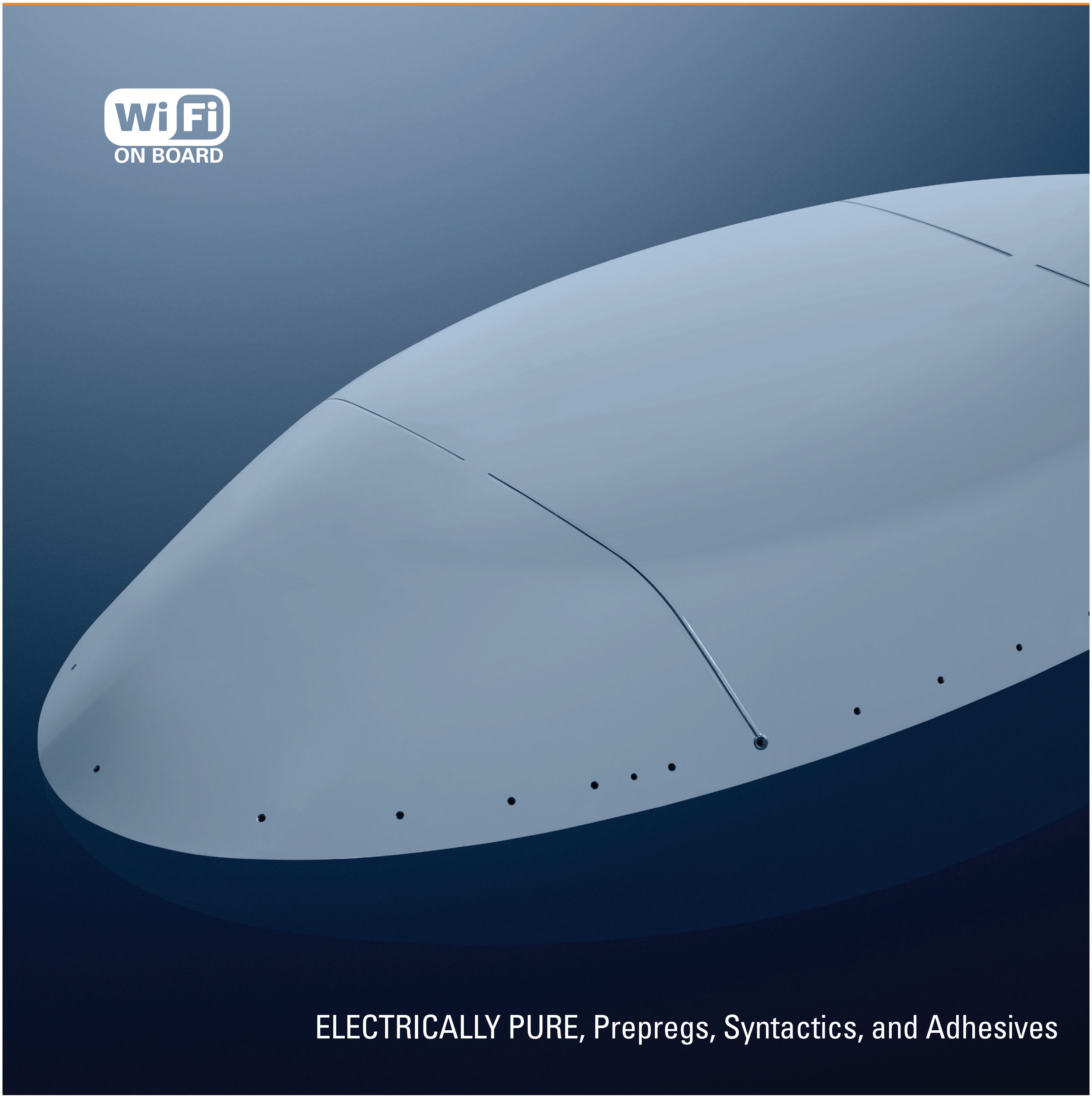
COMPOSITES AID CONNECTIVITY

Radome Antenna Composites



This project was completed under the company name TenCate Advanced Composites, prior to our acquisition by Toray Industries Inc. and name change to Toray Advanced Composites in 2019.

Article from July 2013, High-Performance Composites Magazine.

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